Extracting Bottom Information from Towed-Array Reverberation Data

DEFENCE R&D DÉFENSE

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Background

This poster outlines some of the pioneering work in the use of reverberation measurements for Rapid Environmental Assessment of bottom properties. The use of radar-like polar plots to map sea bottom features had been developed by John Preston in the late 1980s, and demonstrated at SACLANTCEN in the early 1990s.

When the Rapid Response series of REA exercises was begun by NATO MILOC in 1996, the techniques were refined enough to produce maps of scattering features at sea and to extract bottom information through model-data comparisons.

This paper illustrates some of the highlights from the Rapid Response exercises (1996–1998) and follow-on validation exercises as part of NURC/Canada/US Joint Research Projects.

Conclusions

- An entire area can be surveyed in minutes with a single "ping".
- The polar displays are effective in identifying scattering features.
- Bottom properties can be extracted using manual inversion.
- Model-data differences can be used to make a crude map of scattering strength.

Acknowledgements

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NUWC: The Generic Sonar Model was used for many of the reverberation predictions.

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REA Measurement Methodology

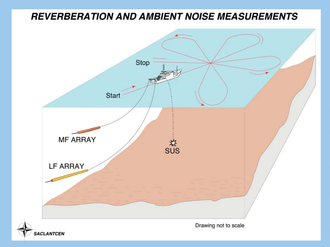
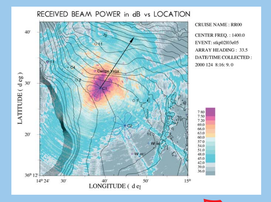


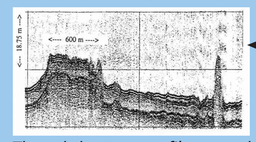
Illustration of array deployment and ship track ("petal pattern") for reverberation and ambient noise experiments.

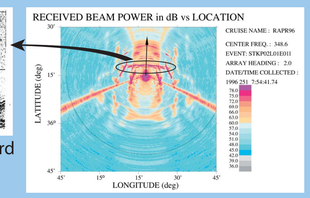
- Make towed array measurements using a petal pattern
- Process data into beams and frequencies
- Produce polar plots; sometimes stack to remove ambiguity
- Identify interesting features; post to REA website.
- Use model-data differences to produce maps of scattering strength

Oil rig, wrecks and mud volcanos are scattering features on the Malta Plateau



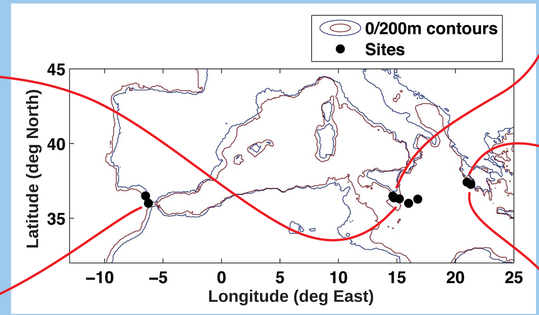
Polar plot from a shallow water site on the Malta Plateau, showing a strong uncharted scattering feature





The sub-bottom profiler record illustrates a possible cause of the strong scattering.

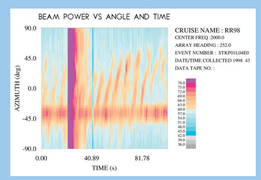
Sites of Mediterranean Reverberation Measurements



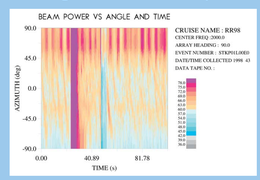
Rapid Response Exercises:
1996: Malta Plateau and Ionian Basin
1997: Ionian Basin & Kyparissiakos Gulf
1998: Atlantic, off Spain

Boundary and Clutter Experiments:
2000, 2002, 2004, 2007: Malta Plateau
2001: New Jersey Shelf and Scotian Shelf

Sometimes "scattering features" are artifacts: beam-time plots of waves breaking over towed array



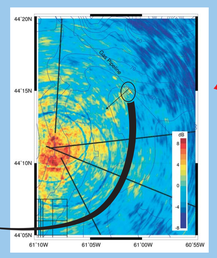
Ship sailing with waves



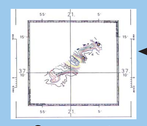
Ship heading into waves

Stacked polar plot of model-data differences on the Scotian Shelf

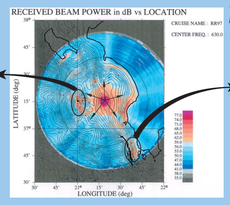
Various geoclutter features are illustrated, including a possible specular return from a natural gas pipeline.

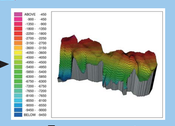


Stacked polar plot from Kyparissiakos Gulf reveals uncharted seamount and misaligned escarpment



Seamount



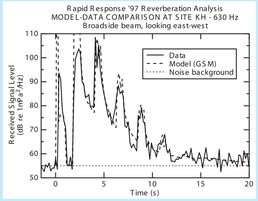


Escarpment

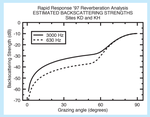
REA Modelling Methodology

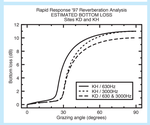
- Premodelling: Process data into beams and frequencies. Choose a quiet beam without significant noise or scattering features.
- Use measured sound speed profile, water depth, and array geometry, together with best available bottom information
- Model reverberation including broadband array beam patterns
- Manually adjust the bottom loss and scattering strength to get reasonable fit. Check across other beams and frequencies.
- Create polar plot using model-data differences for all beams.

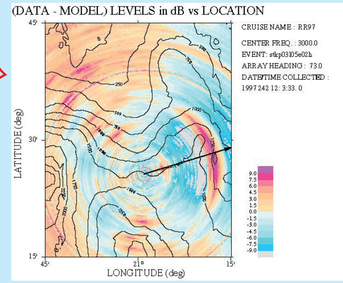
Sample Model-Data Comparison



Line plot of model-data differences (left); extracted bottom loss and backscatter (right).







Scattering "Map"

Polar plot of model-data differences at 3 kHz. Single plot has "left-right" ambiguity.

Typical Bottom Parameters Extracted during Rapid Response 97; Ionian Basin (Site IA), Kyparissiakos Gulf (Sites KD and KH)

Site	Frequency (HZ)	Bottom loss at 90° (dB)	Lambert coefficient (dB)	Facet strength (dB)	Facet width (dB)
IA	160	16	-31	-15	15
IA	350	19	-32	-20	15
IA	630	16	-32	-20	15
IA	800	13	-34	-15	12
IA	1400	15	-35	-20	15
IA	3000	13	-32	-15	7
KD	630	10	-35	-10	10
KD	3000	10	-27	-10	10
KH	630	11	-35	-10	10
KH	3000	11	-27	-10	10